Comments to EPA Science Advisory Board on the proposed accounting of carbon emissions from combustion of forest bioenergy.

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The attempt to find a way to account for forest bioenergy carbon *emissions* has been largely solved by the Life Cycle Assessment and Systems Dynamics Analysis of the carbon stock additions to the atmosphere over time. The use of arbitrary time frames and the debate over what is appropriate should replacement forest growth take place is no longer necessary. Following the carbon from trees to fuel to combustion release as atmospheric CO_2, and its potential removal by replacement tree photosynthesis is now well described by recent findings (Sterman et al, by Law et al, Birdsey et al and by Booth).

This full-time accounting of carbon as it moves through natural and human energy systems also allows direct comparison with alternative scenarios for producing heat and/or electricity. The result is that forest bioenergy adds more carbon dioxide to the atmosphere over time frames of a century or more than do alternative energy sources.

The other point to be made is that the focus on when – if ever – bioenergy becomes carbon neutral is the wrong question to be asking. Climate change needs to be addressed as rapidly as possible in order to avoid reaching irreversible tipping points. The goal that truly matters is clearly stated in Article 2 of the UN Framework Convention on Climate Change.

> "The ultimate objective … is to achieve… stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

It is quite clear that current CO_2 and other greenhouse gases are already causing "dangerous anthropogenic interference with the climate system." Human activities have increased concentrations of CO_2 to 411ppm; well above the 280 ppm that prevailed before large-scale additions from all forms of combustion including bioenergy, and land use change including deforestation, destruction of wetlands and degradation of grasslands and agricultural soils. The combined removal of CO_2 by these terrestrial ecosystems reduces the annual increase of atmospheric CO_2 by about 30% by removing some 3 GtC/year from the atmosphere. (Le Quere et al)

Hence the counterfactual or alternative scenario to be considered is how much more or less atmospheric concentrations of carbon dioxide would there be if forest bioenergy were not used at all. How much more would forests grow and how much more CO_2 would they have absorbed and removed from the atmosphere had they been able to continue growing instead of being cut and burned? How much larger would the terrestrial carbon sink be in this alternative scenario? The carbon is either in the trees and soils and ocean, or it is in the atmosphere.

It is now well established that larger older trees store the bulk of carbon in the living biomass of the forests. A recent study of 48 forest plots in all types of forests found that half of the carbon in living biomass is stored in the largest one percent diameter trees (Lutz et al). Additional studies show that half of all the carbon in forests is in soils and dead biomass (Birdsey, Moomaw et al). In other words, forests made up of larger, older trees hold more carbon than do younger smaller ones. Also, because many species can live for several centuries, they continue to add much larger amounts of carbon in their middle to later years than do forests made up of younger smaller trees.

It is often argued, "sustainable forest management is carbon neutral." That is usually taken to mean that continual annual harvests take no more carbon than grows in that year. This assumes that replacement trees are only removing and storing carbon from the previous combustion of wood many decades before, and ignores the fossil fuel carbon removal that has been displaced. What is also missing from the analysis is the carbon stock in the forest. With short rotations, the stock of stored carbon is small, and so there is always more carbon in the atmosphere.

Applied to the carbon balance for a forest sustainably managed for bioenergy this has a further important implication. Suppose a forest is harvested after 50 years for bioenergy, and it is burned immediately, releasing carbon into the atmosphere. A replacement forest must then grow for at least 50 years to assure carbon neutrality. The economic benefit of that future CO_2 removal should be appropriately discounted. Physically, during that time, the concentration of CO_2 in the atmosphere is greater than it would have been had the trees not been cut and burned and trapping additional heat. The extra CO_2 has irreversible consequences, acidifying the oceans, and the warmer temperature melts ice and increases sea level. These changes are not reversed once the replacement forest has grown in 50 years. *Carbon neutrality* is not the same as *climate neutrality.*

It is important to consider an alternative scenario that spans several harvest cycles. If allowed to continue growing instead of being again cut and burned, the forest would sequester substantially larger amounts of carbon dioxide during the additional 50 years than in the initial 50-year interval. The stored carbon additions will continue to increase well into the life of the trees, and may continue to do so for several centuries instead of decades (Birdsey et al). If we are to actually reduce atmospheric carbon dioxide concentrations, it is essential that we stop adding carbon dioxide from all combustion sources including bioenergy, and increase the removal rates and carbon storage in terrestrial ecosystems including forests. Long-lived forests are our best option for increasing negative emissions over time.

In the discussion above several important additional sources of emissions from bioenergy have been left out. Forest bioenergy releases more CO2 per BTU or kWh than any fossil fuel at the stack. Significant amounts of fossil fuel energy are required to produce commercial scale wood pellets and chips, and not all of what is harvested is utilized in the final fuel. Each successive harvest removes soil nutrients that must be added in the form of fertilizer, and the nitrous oxide from fertilizer substantially increases radiative forcing. There is no enforcement mechanism to ensure a replacement forest is planted. In short, forest bioenergy cannot be justified on grounds of being a low carbon energy source. Fortunately, there are many alternative low carbon technologies to produce electricity and heat.

References

Richard Birdsey, William Moomaw, Richard Houghton, Wayne Walker, Phillip Duffy (2018). "Limits to Growth of Forest Biomass" Underestimates Carbon Sequestration Potential of Old-growth Forests, Nature Communications (In Press)

Richard Birdsey Philip Duffy, Carolyn Smyth, Werner A Kurz, Alexa J Dugan and Richard Houghton (2018). Climate, economic, and environmental impacts of producing wood for bioenergy. Environmental Research Letters, Volume 13, Number 5, **http://iopscience.iop.org/article/10.1088/1748-9326/aab9d5**

M S Booth, Assessing the net emissions impact of residues burned for *bioenergy*. To cite this article: *Mary* S *Booth* (2018) Environ. Res. Lett. 13 035001.

Beverly E. Law, Tara W. Hudiburg, Logan T. Berner, Jeffrey J. Kent, Polly C. Buotte and Mark E. Harmon (2018). Land use strategies to mitigate climate change in carbon dense temperate forests. PNAS April 3, 2018. 115 (14) 3663-3668; published ahead of print March 19, 2018. https://doi.org/10.1073/pnas.1720064115

LeQuere et al (2018). Earth Syst. Sci. Data, 10, 405–448. https://doi.org/10.5194/essd-10-405-2018

James Lutz et al Inequality is Normal: Dominance of big trees (2018). Global Ecology and Biogeography https://onlinelibrary.wiley.com/doi/abs/10.1111/geb.12747

John D Sterman, Lori Siegel and Juliette N Rooney-Varga (2018), Does replacing coal with wood lower CO_2 emissions? Dynamic lifecycle analysis of wood bioenergy, 2018. Environment Research letters, Volume 13, Number 1. http://iopscioence.iop.org/article/10.1088/1748-9326/aab512